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14. ABSTRACT
2013 North American Molecular Beam Epitaxy Conference -Post-Conference Workshops,, Banff, Alberta, Canada (October 5-11 2013)

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Report Title

New Approaches for Characterization of Heterogeneous Material Integration Quality

ABSTRACT

2013 North American Molecular Beam Epitaxy Conference -Post-Conference Workshops,, Banff, Alberta, Canada (October 5-11 2013)

TEXAS STATE UNIVERSITY®
SAN MARCOS
The rising STAR of Texas

NAMBE 2013
Banff Centre in Banff, Alberta • October 5-11, 2013
30TH NORTH AMERICAN MOLECULAR BEAM EPITAXY CONFERENCE

New Approaches for Characterization of Heterogeneous Material Integration Quality

Tom Myers

Materials Science, Engineering, and Commercialization Program
Texas State University – San Marcos

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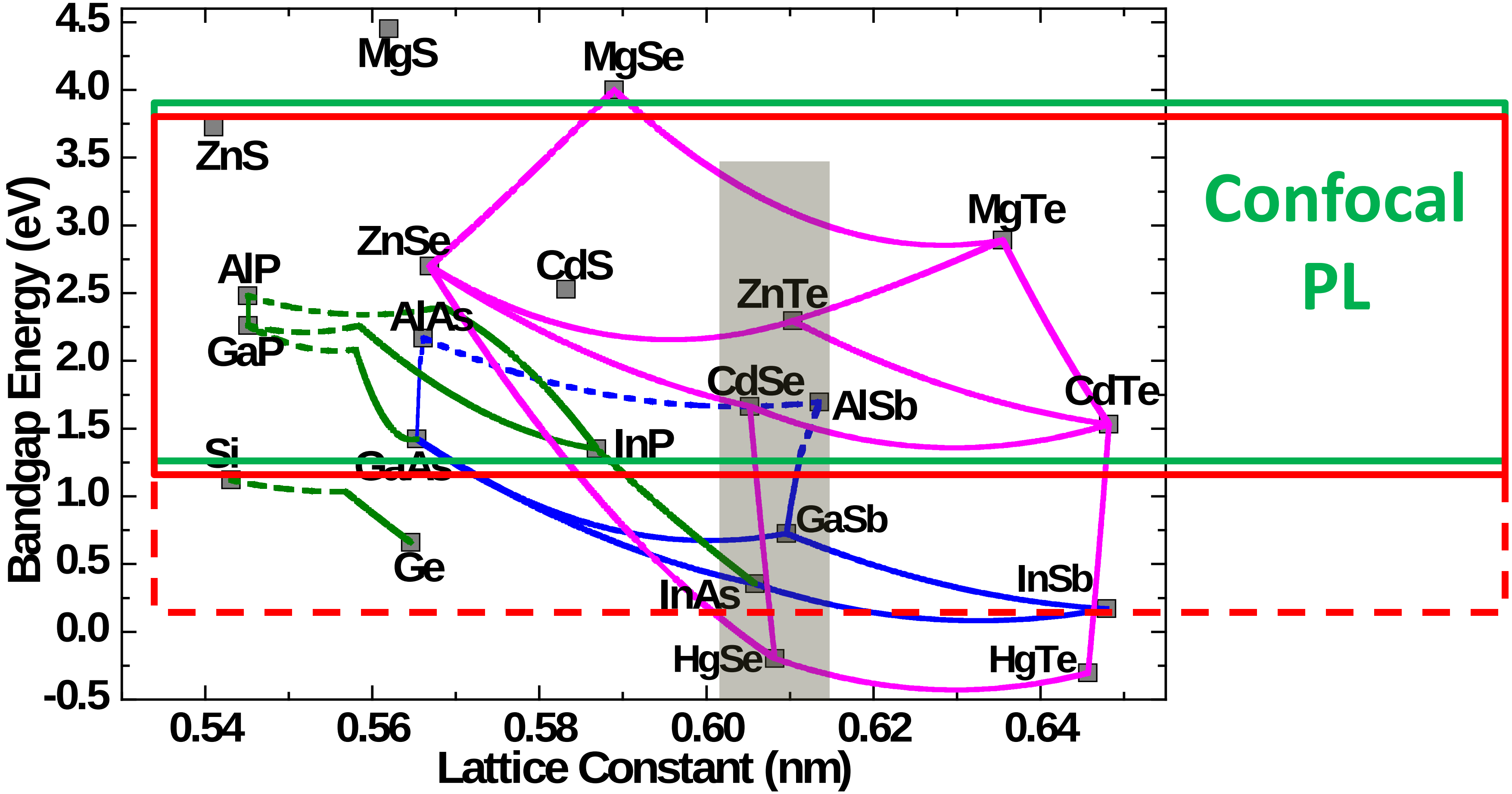
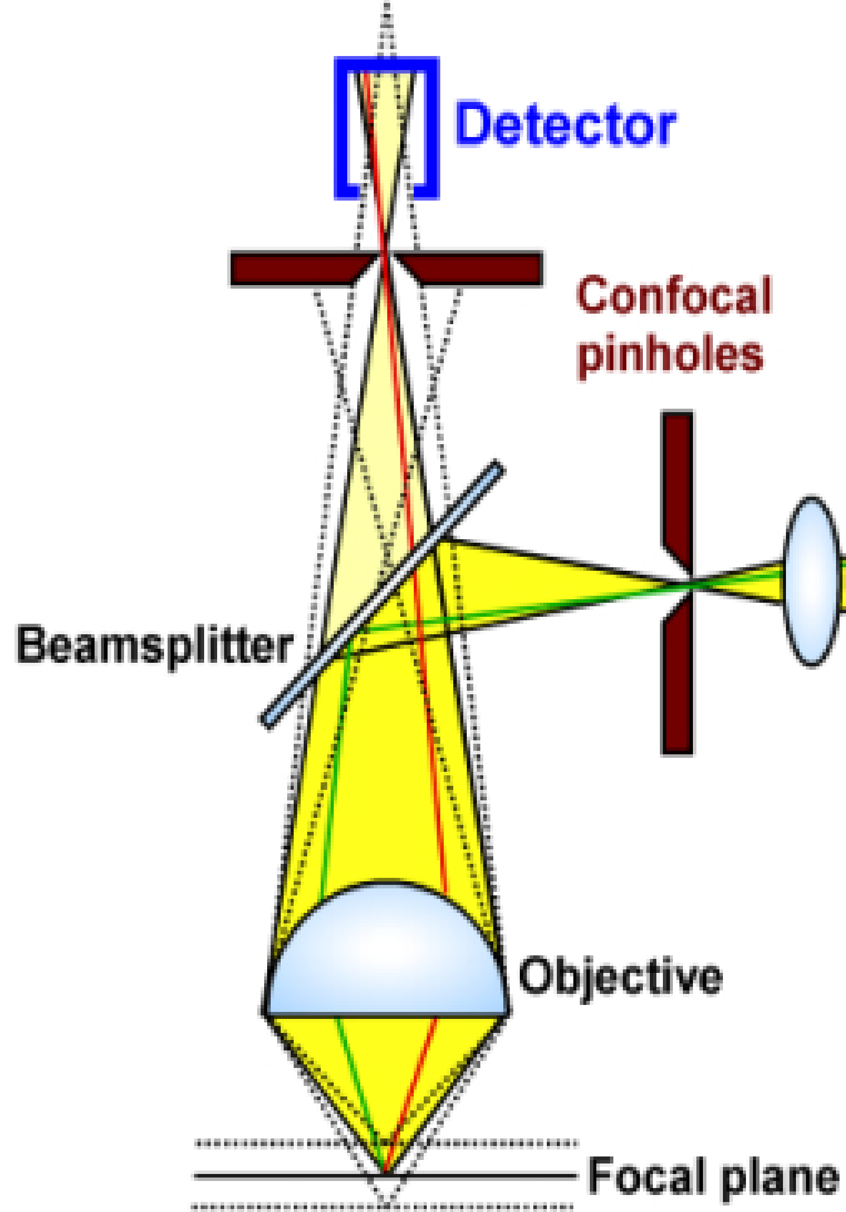
Cathodoluminescence



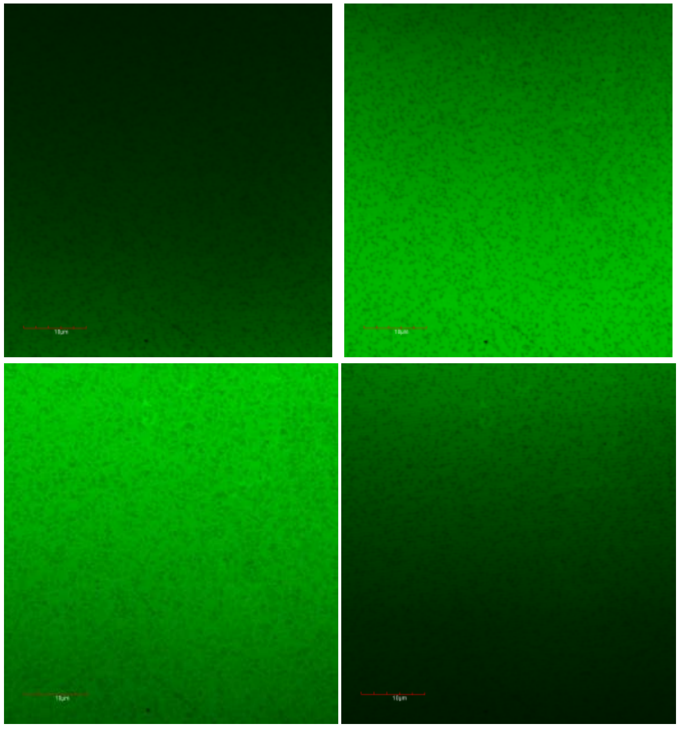
The 6.1 Å Alloy System can be used to grow a host of nearly lattice matched materials (III-V and II-VI), from infrared to UV

Laser Confocal Microscopy (Confocal PL)



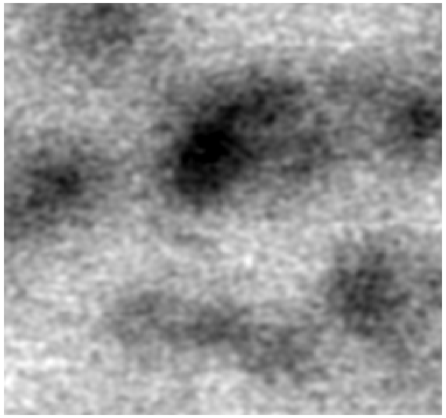
Lateral Resolution 0.25 μm
Depth Resolution 0.25-0.5 μm

0.25 μm Steps on 0.25 μm Thick ZnTe

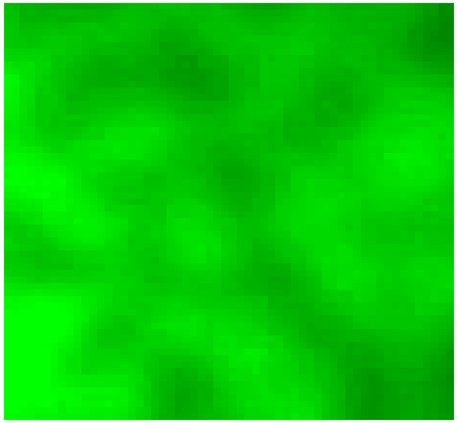


Confocal PL provides highest contrast

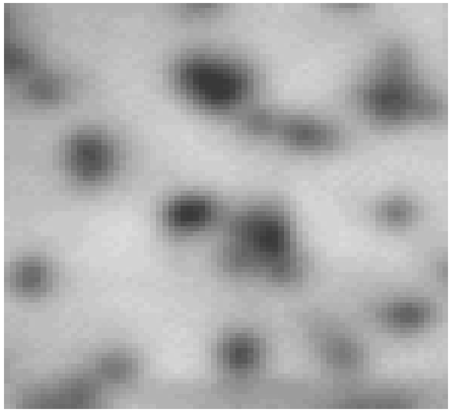
Cathodoluminescence



Imaging Photoluminescence



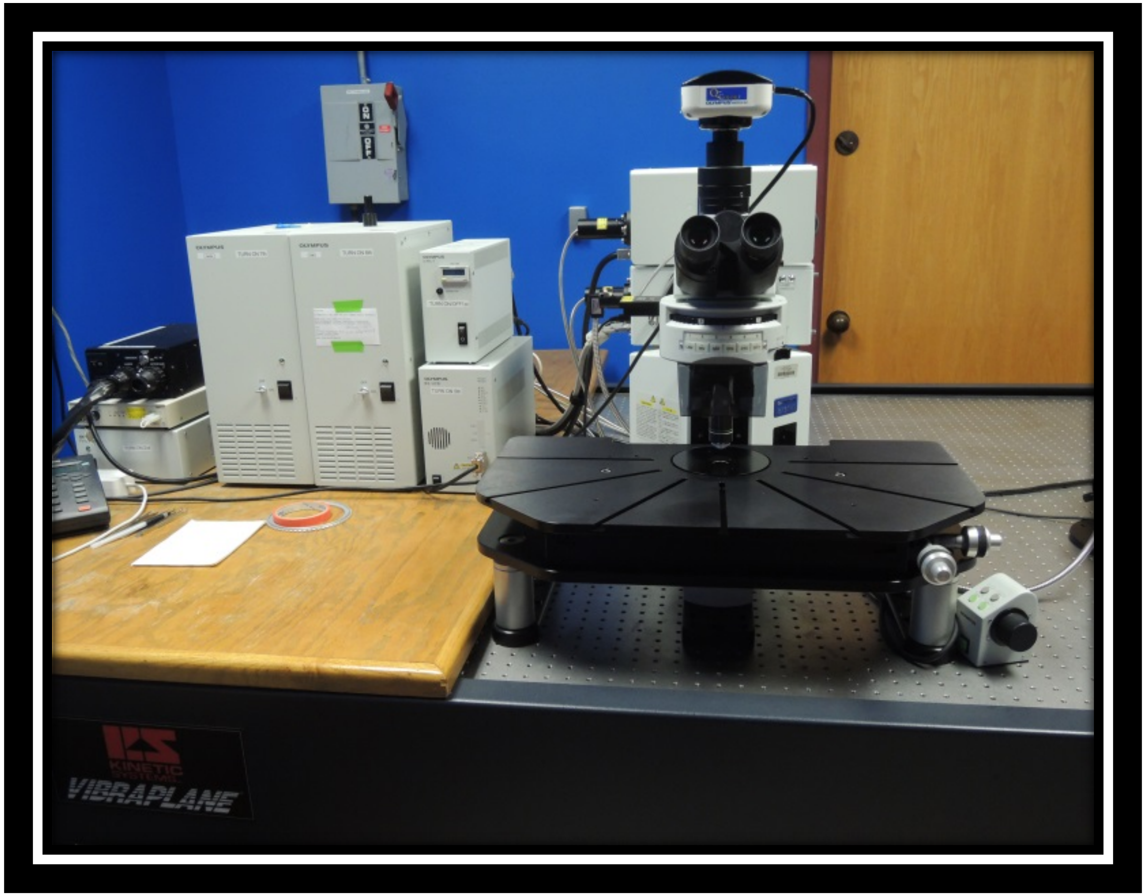
Confocal Photoluminescence



5 μm

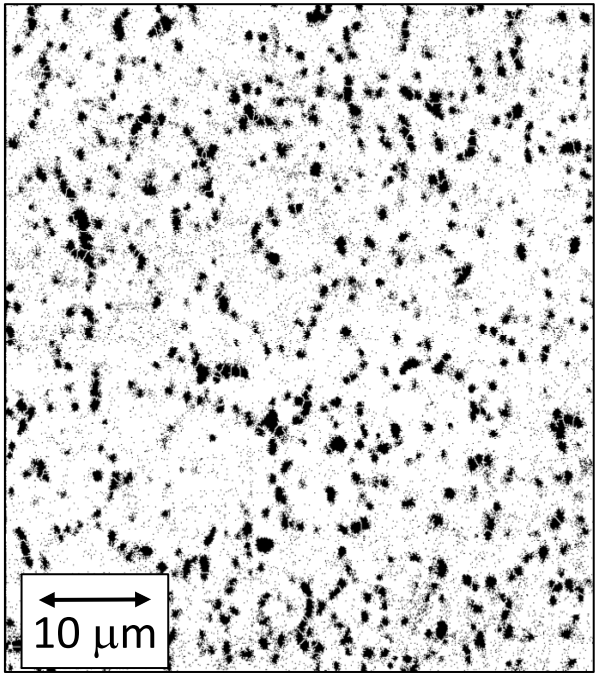
1000 nm ZnTe

Olympus FV1000 Laser Scanning Confocal Microscope

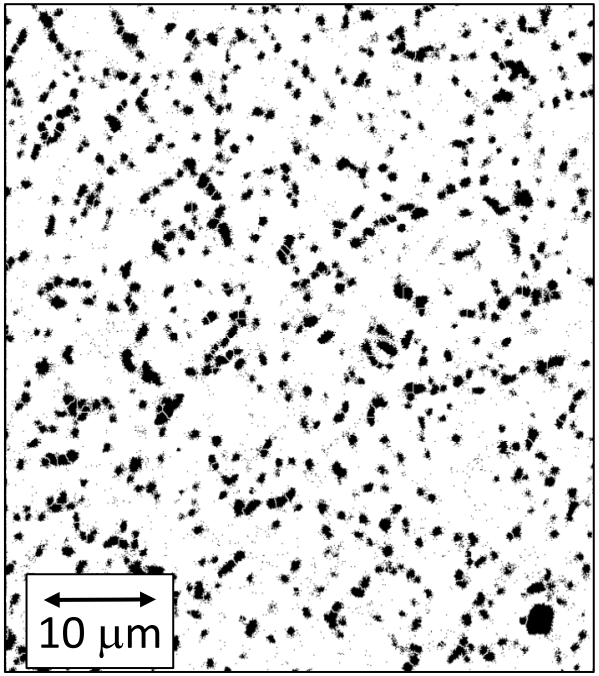


- high-resolution confocal observation of fixed and living cells,
- point-detection, variable bandwidth filtering, 3-D imaging, and time experiments.
- multi-line Argon lasers: 515, 488, and 458, and Diode lasers 405, 559, and 635. brightfield or DIC imaging,
- motorized upright microscope.

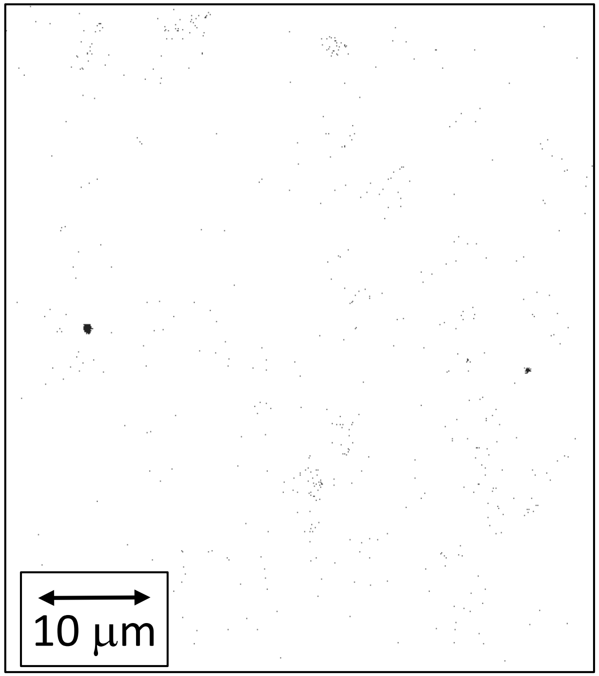
Effect of Lattice Matching



$\sim 3 \times 10^7$ cm^{-2}
2-μm thick
ZnTe/GaSb (211)B

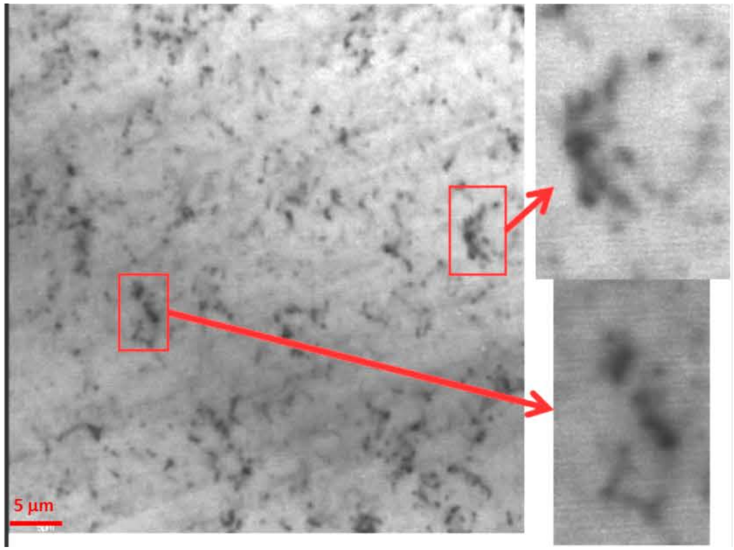


$\sim 3 \times 10^7$ cm^{-2}
2-μm thick
ZnTe/GaSb (100)

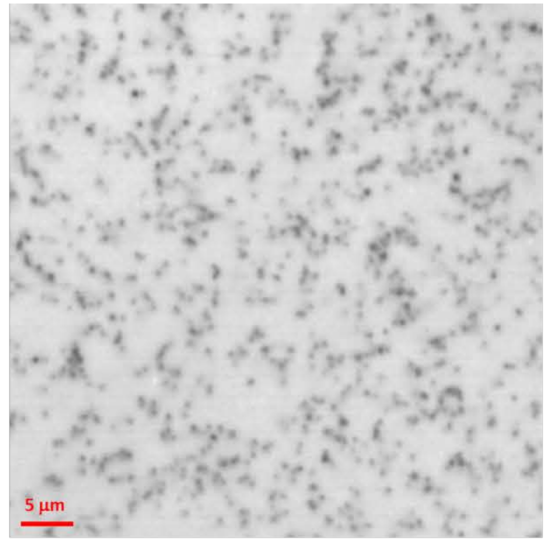


$\sim 7 \times 10^4$ cm^{-2}
1.2-μm thick
$ZnTe_{0.99}Se_{0.01}$/
GaSb (211)B

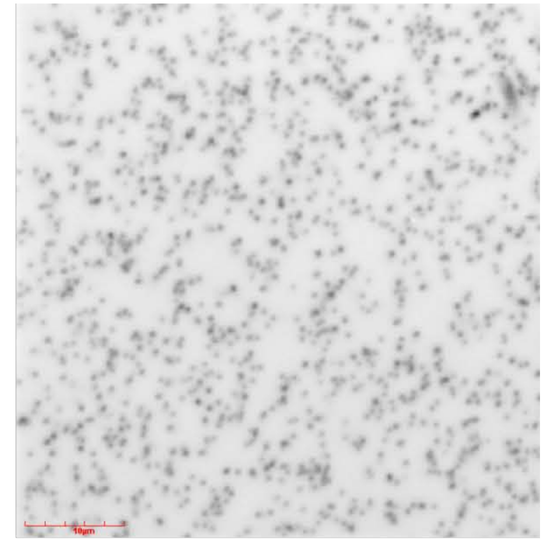
Evaluation of II-VI Growth on Alternative Substrates



c-PL micrograph of ZnTe/Si suggestive of dislocation clustering with a measured “dislocation” density of $2x10^7cm^{-2}$

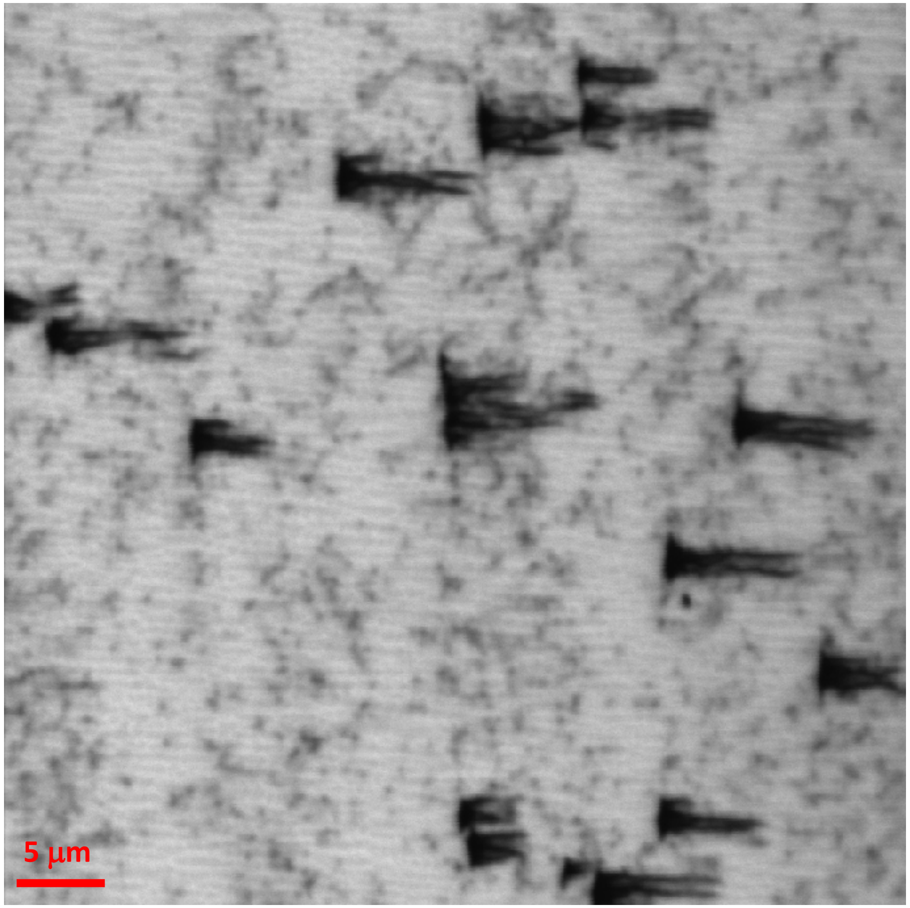


c-PL micrograph of CdTe/Si less suggestive of dislocation clustering with a measured “dislocation” density of $2x10^7cm^{-2}$



c-PL micrograph of (211)B CdTe/GaAs showing a “non-clustered” defect distribution with a density of $2x10^7cm^{-2}$.

Twin-related Defects



c-PL micrograph of (211)B ZnTe/Si showing twinning occurring during MBE growth

c-PL micrograph of (111)B CdTe/CdTe showing twinning occurring during MBE growth

Cathodoluminescence

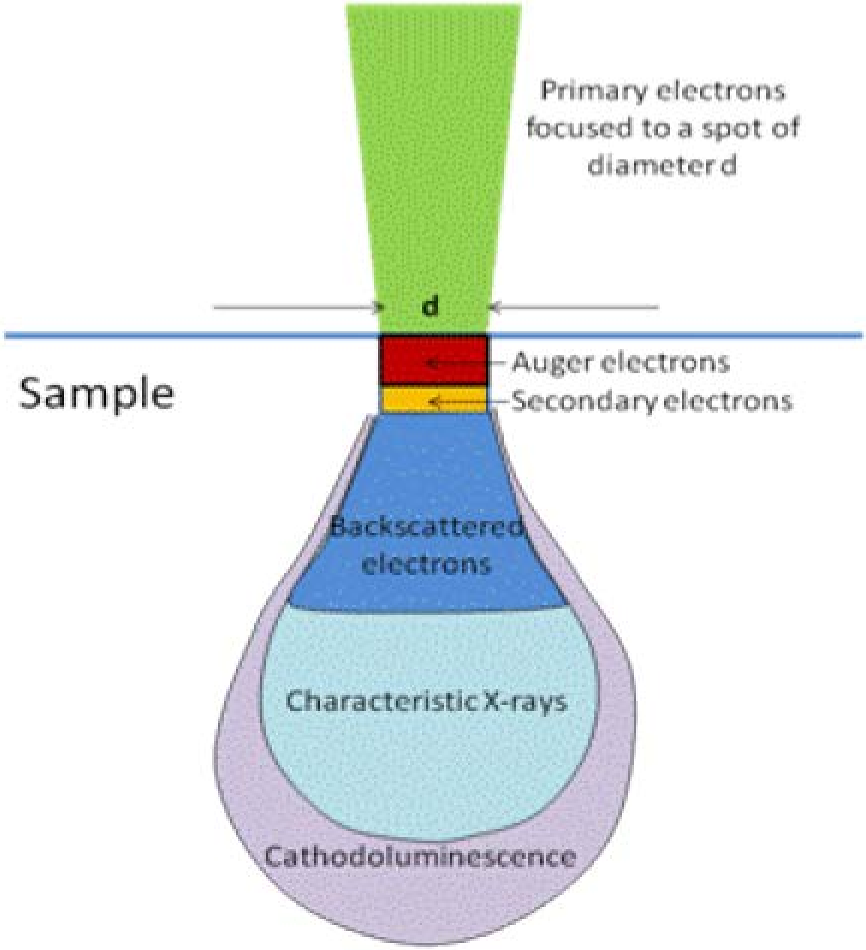
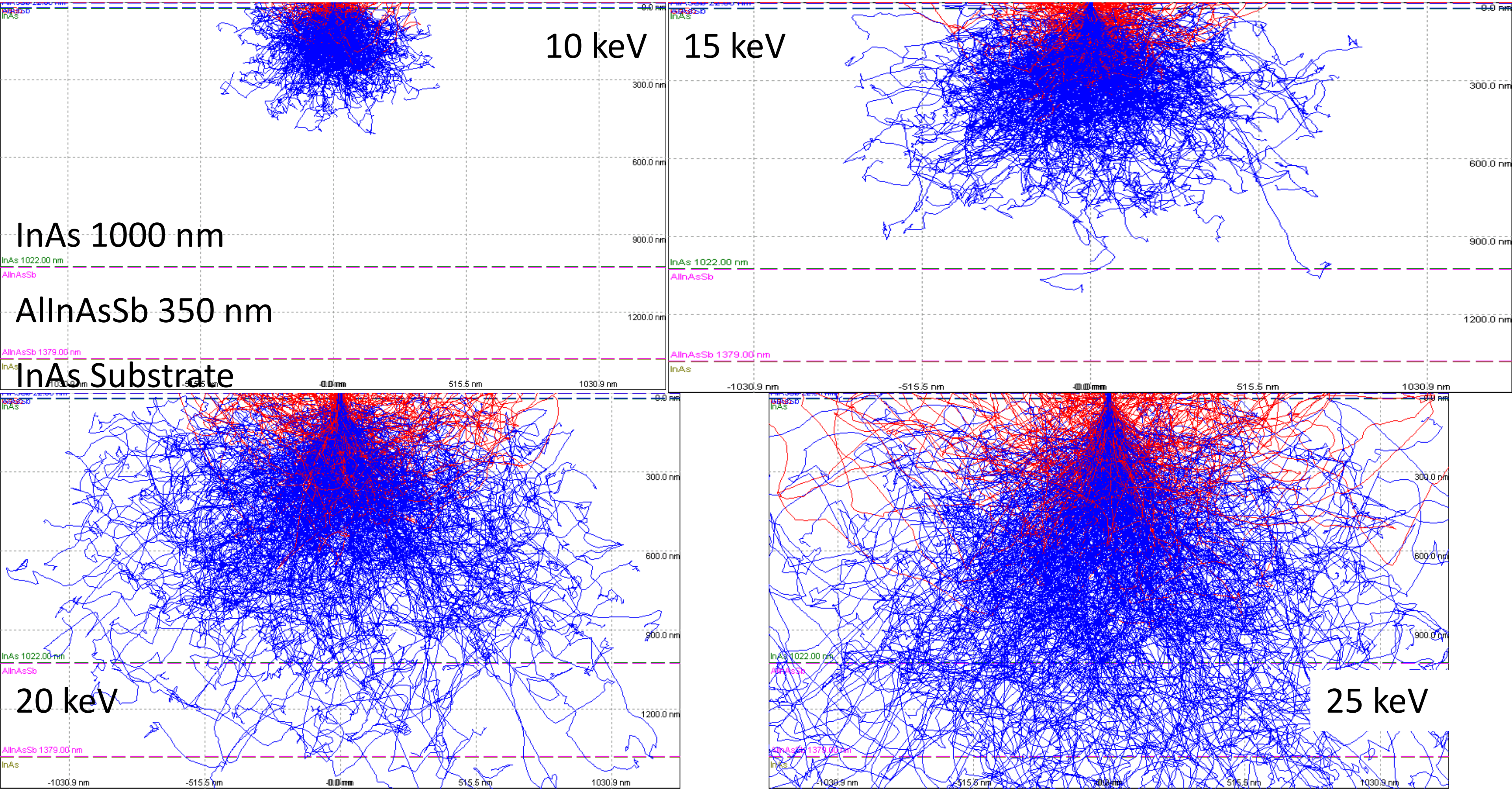
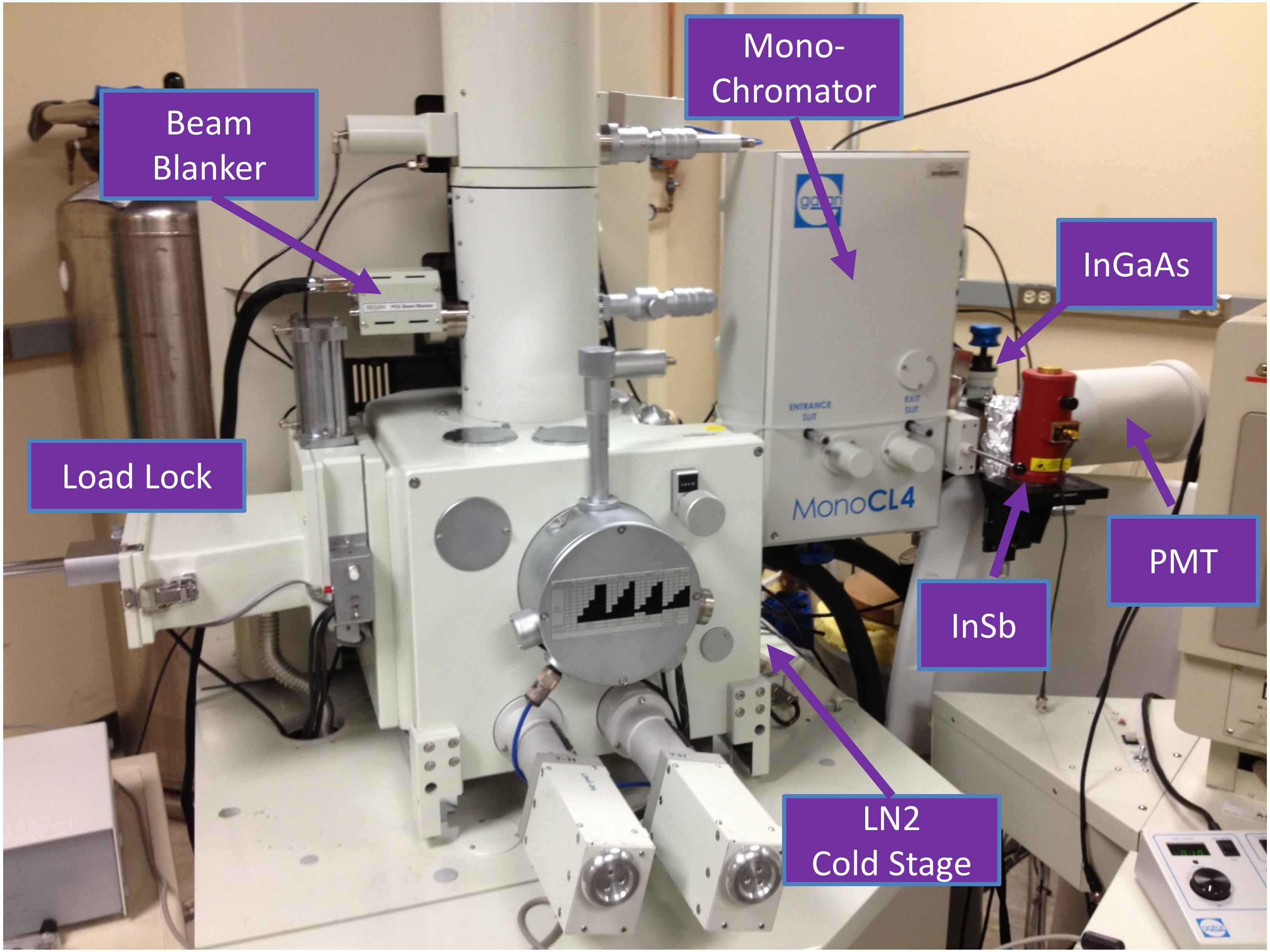
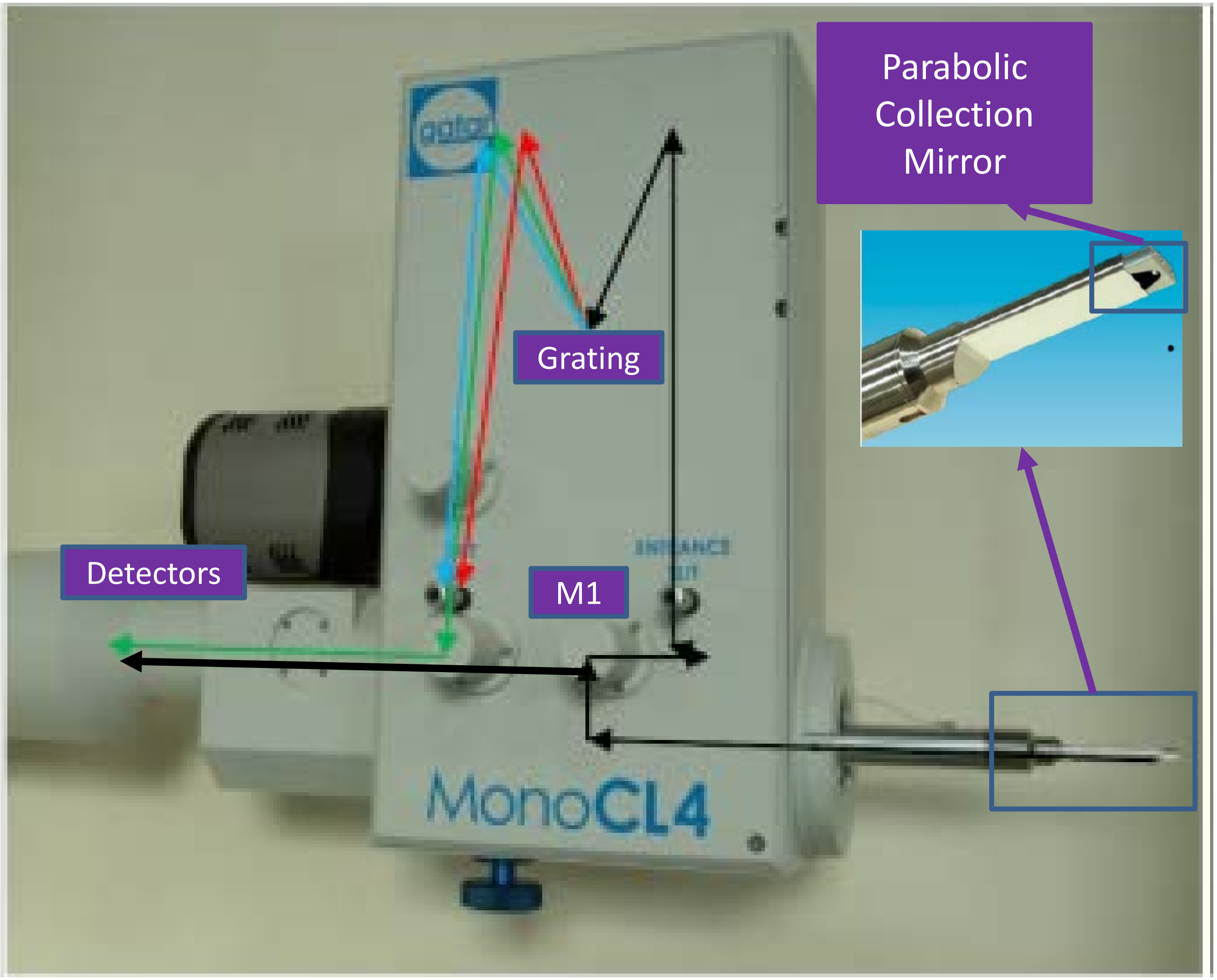


Figure 23 - the generation (interaction) volume and the location of some of the signals generated within it



Simulation of Electron Penetration


Mono-
Chromator
Beam
Blanker
InGaAs
Load Lock
MonoCL4
PMT
InSb
LN2
Cold Stage


Parabolic Collection Mirror
Grating
Detectors
M1
MonoCL4

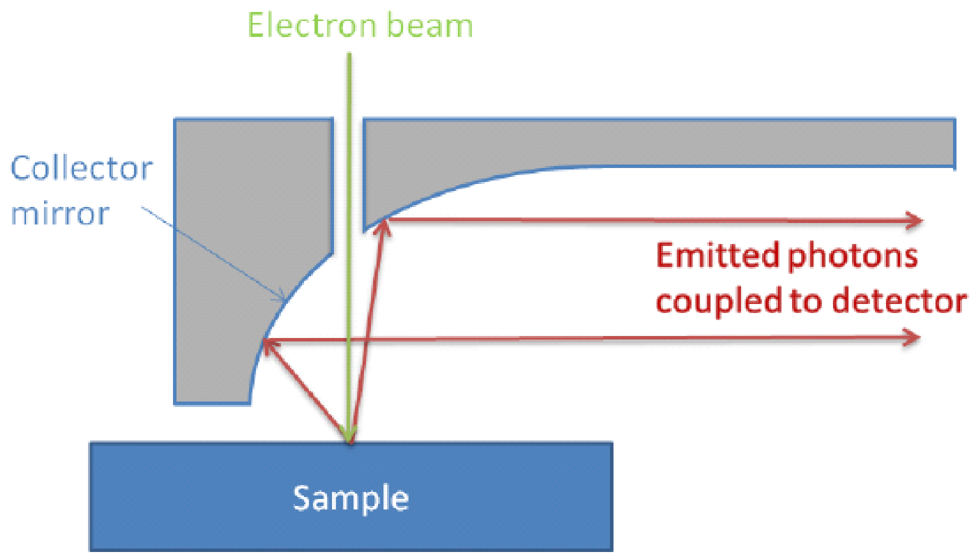
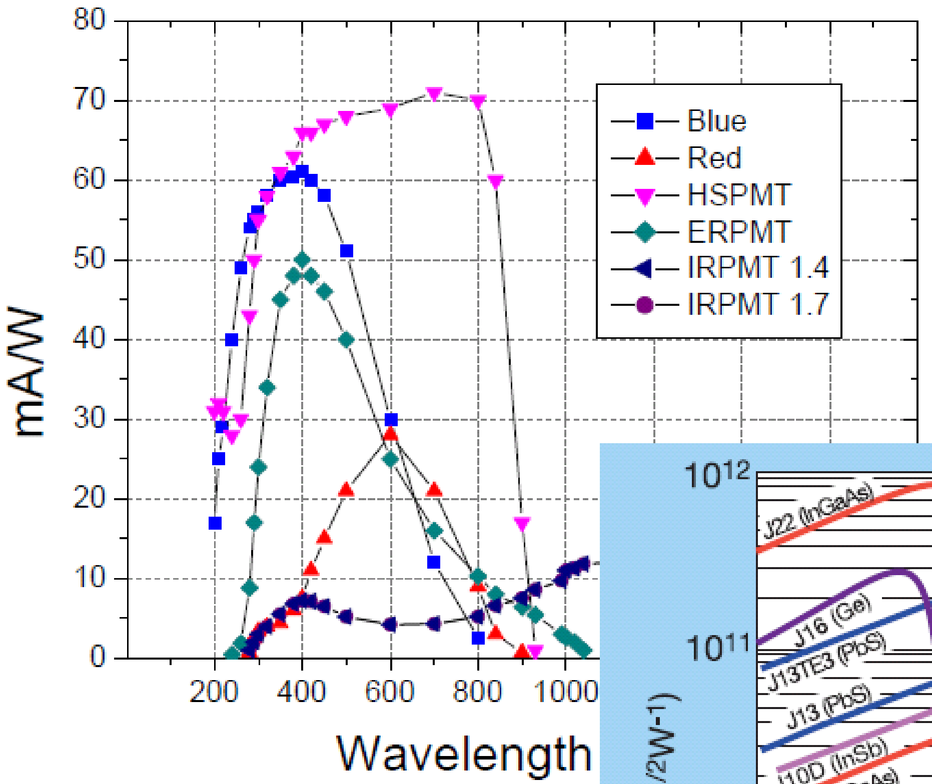
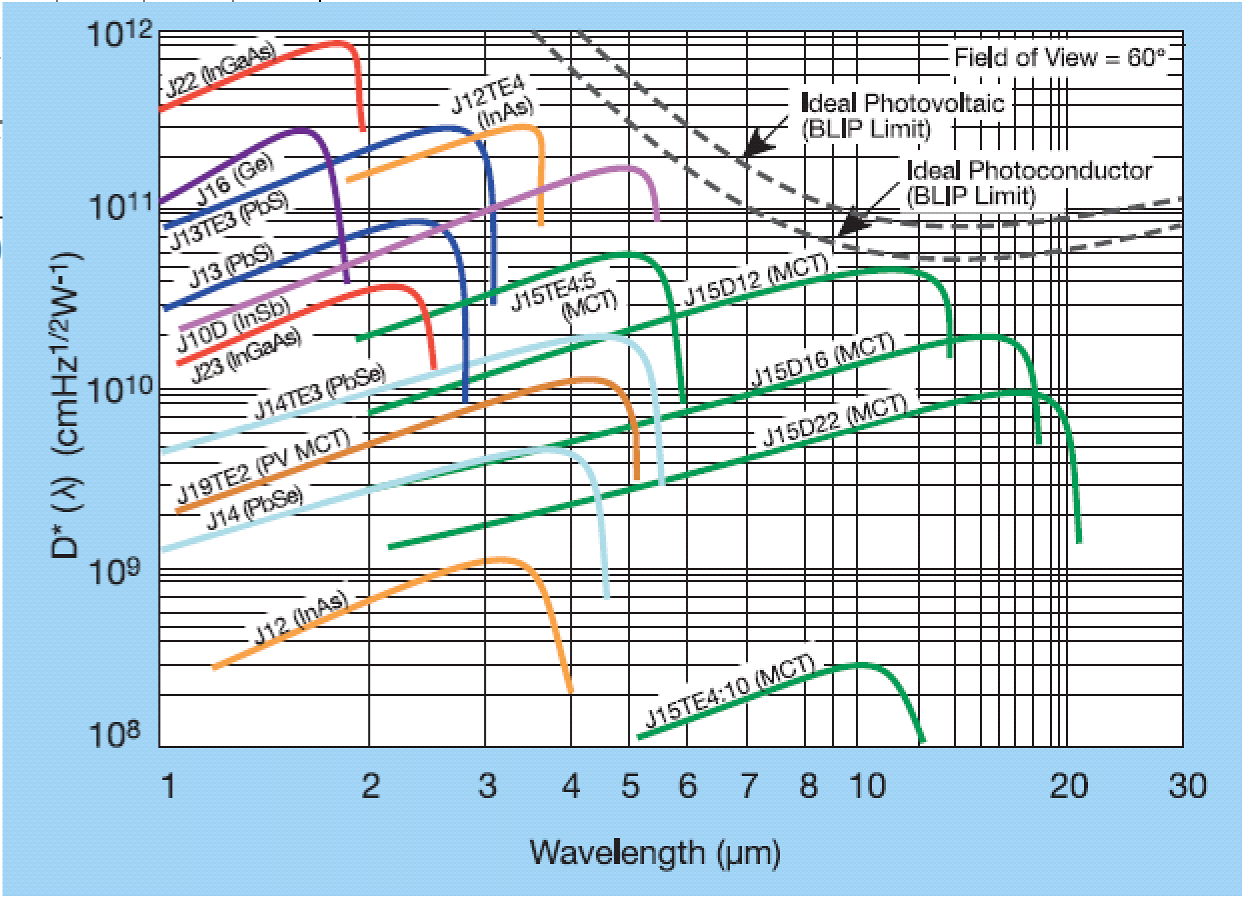


Figure 24 - schematic representation of CL setup with a parabolic mirror used to couple photons efficiently to a detector

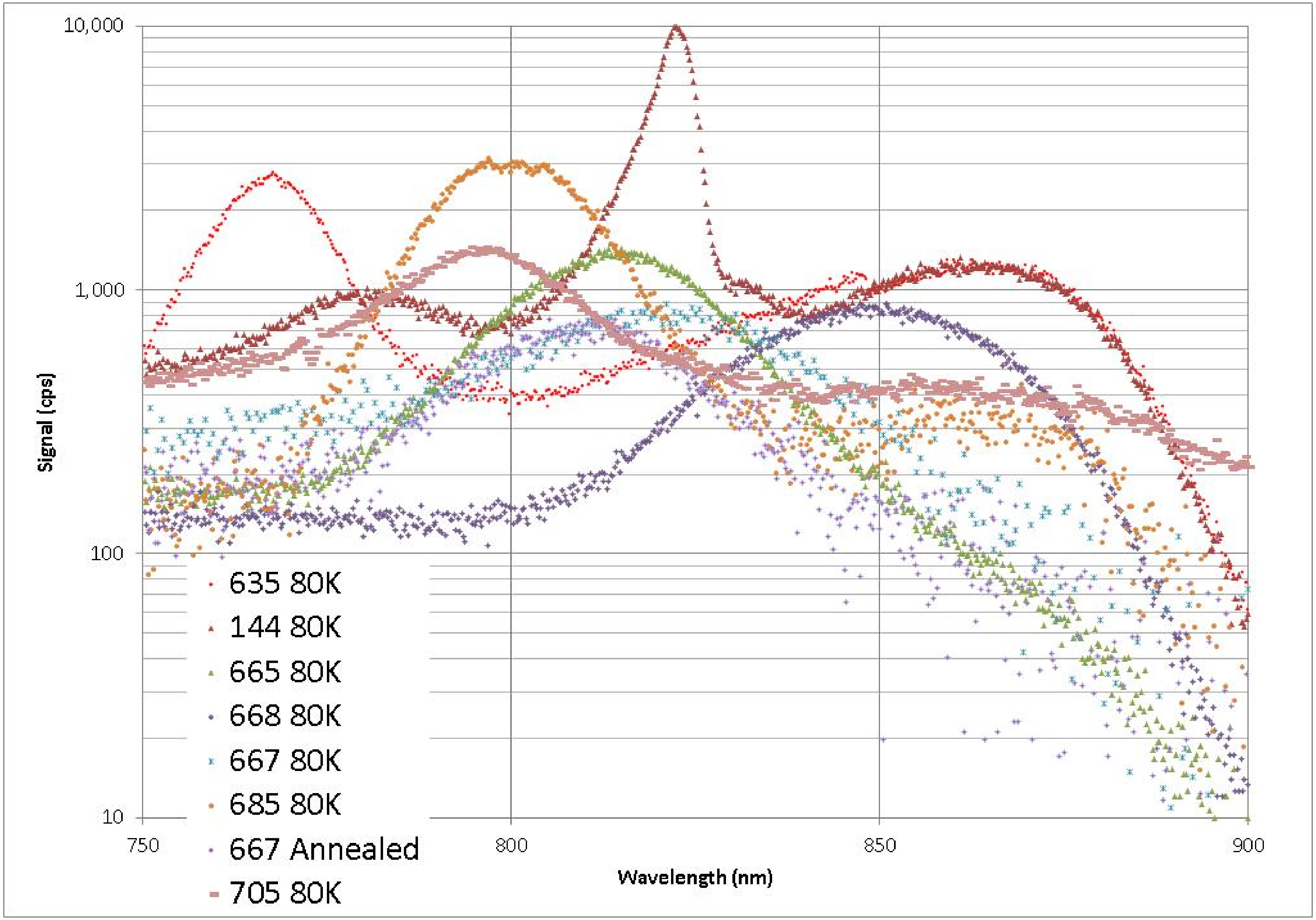
Very High Collection Efficiency
> 75%

Detector Sensitivity

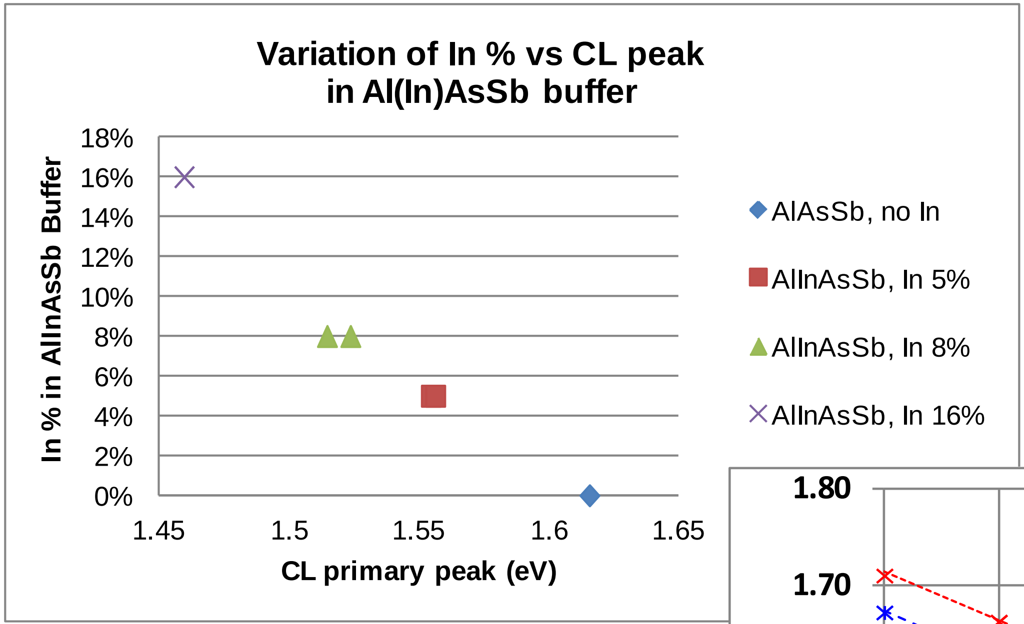


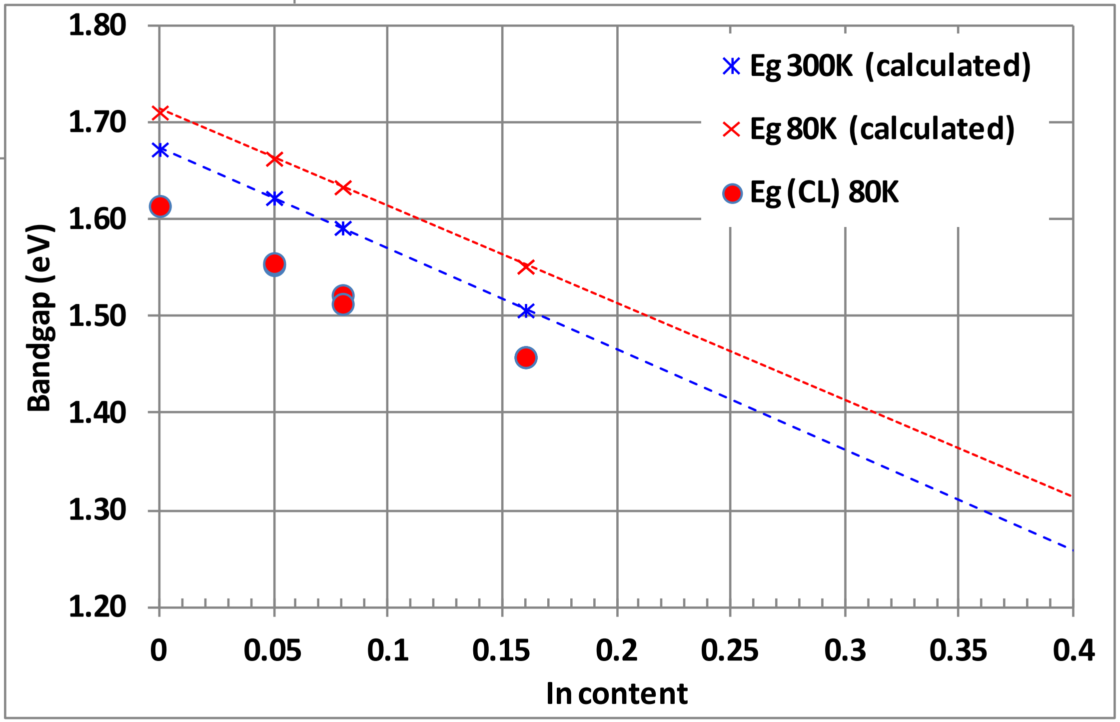


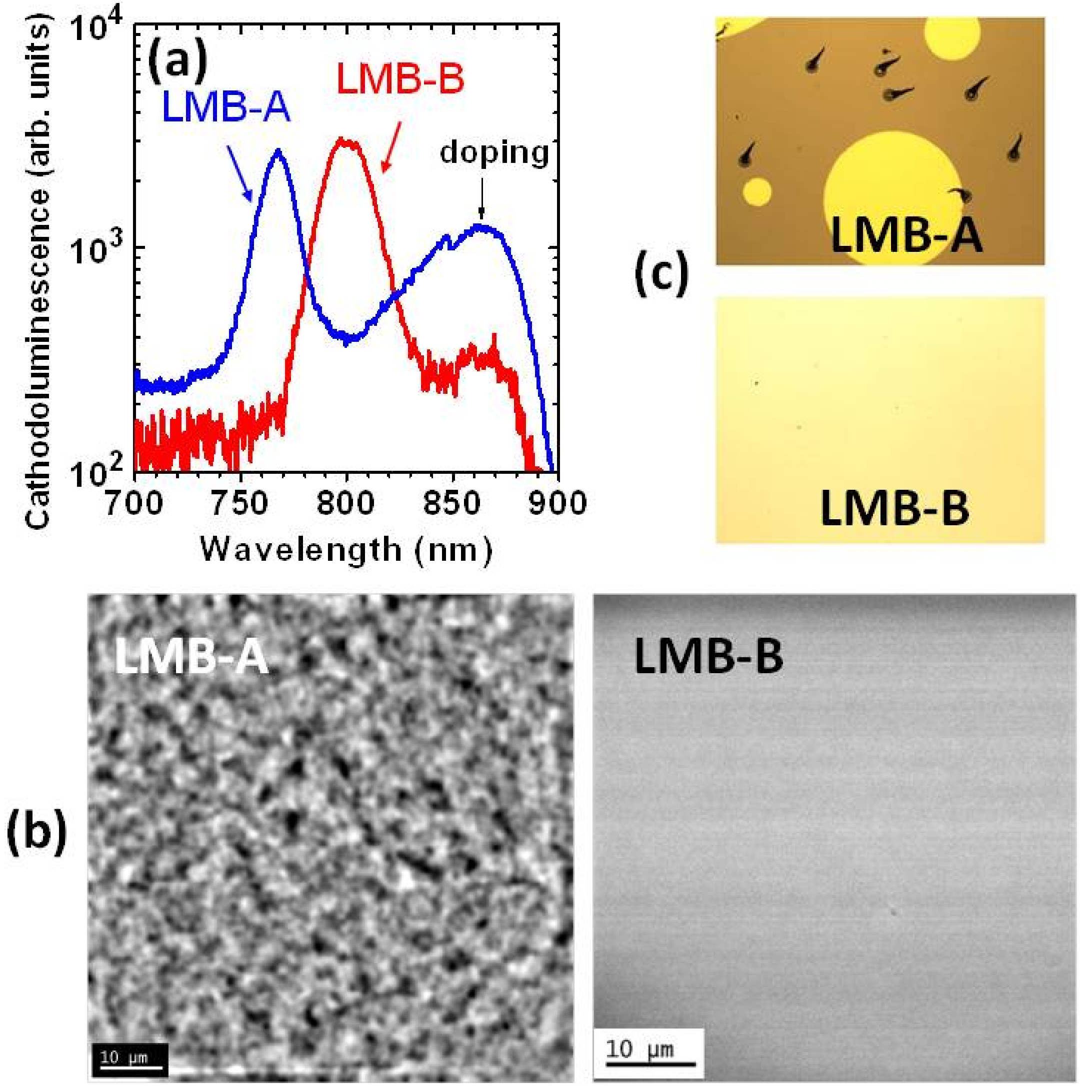
Indirect gap layer - InAlAsSb



Estimated In% and Calculated Eg in AlInAsSb vs Eg from CL Primary Peak

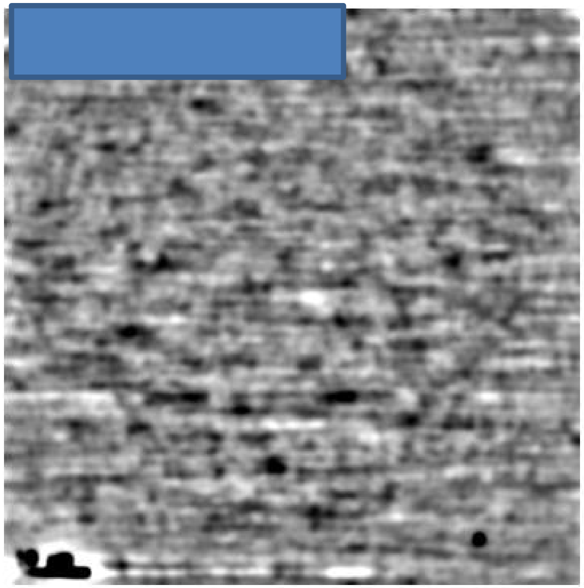


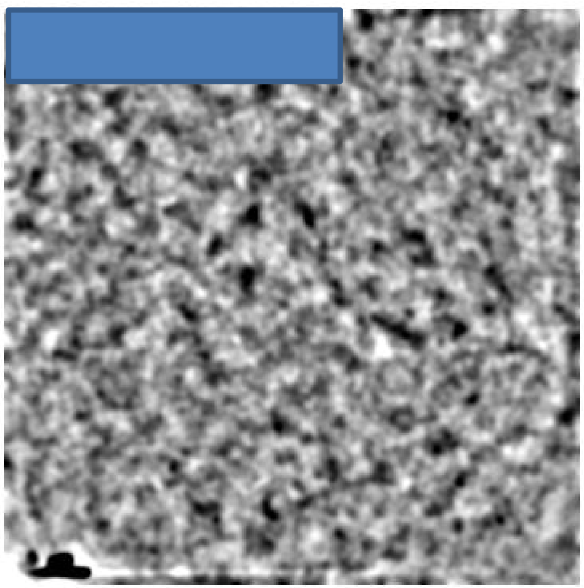




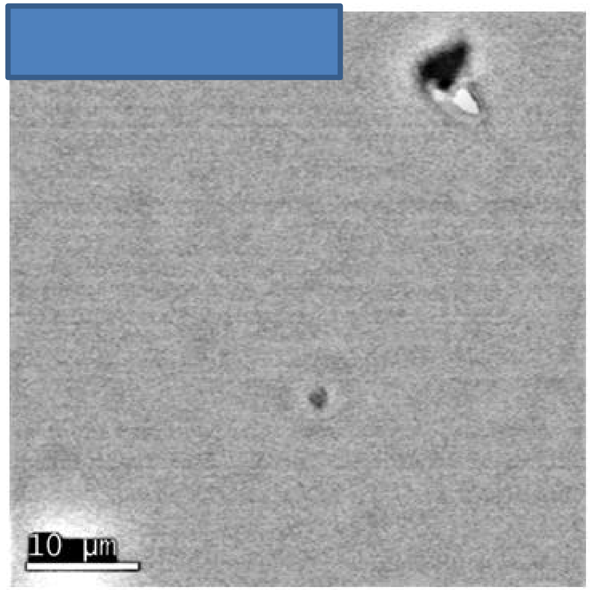
(a) CL spectra, (b) panchromatic CL images, and (c) optical images of the InAs surface after exposure to diluted HF of the LMB-A and LMB-B structures of Fig. 4. Defectivity of LMB-A is only revealed in CL images (b) and manifested by attack of defect sites (c).

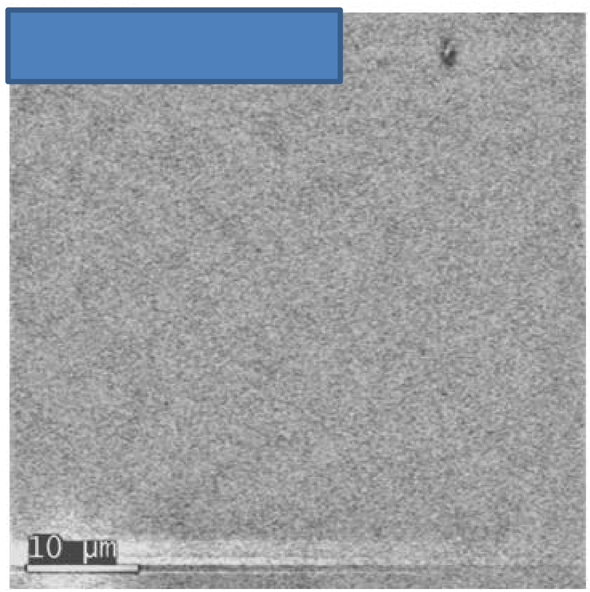
CL Image Comparison AlInAsSb Different growth conditions (80K)



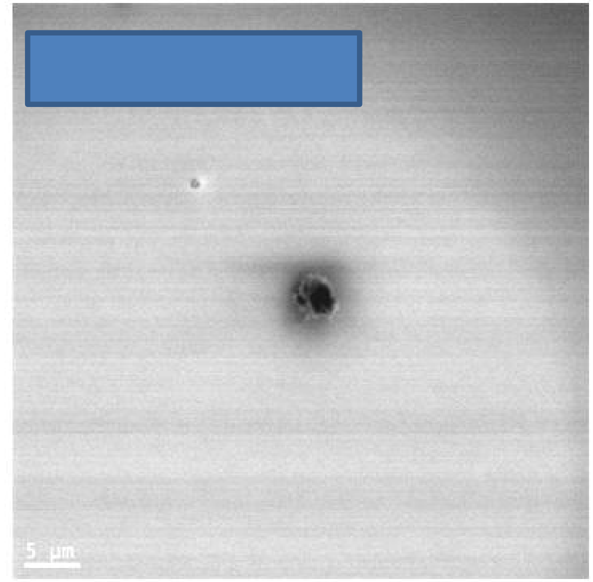


Defect density ~ 10^{9} cm^{-2}

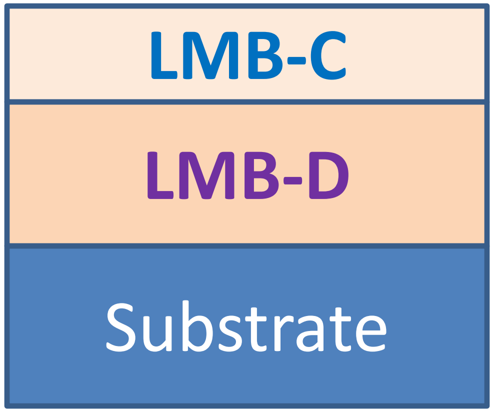


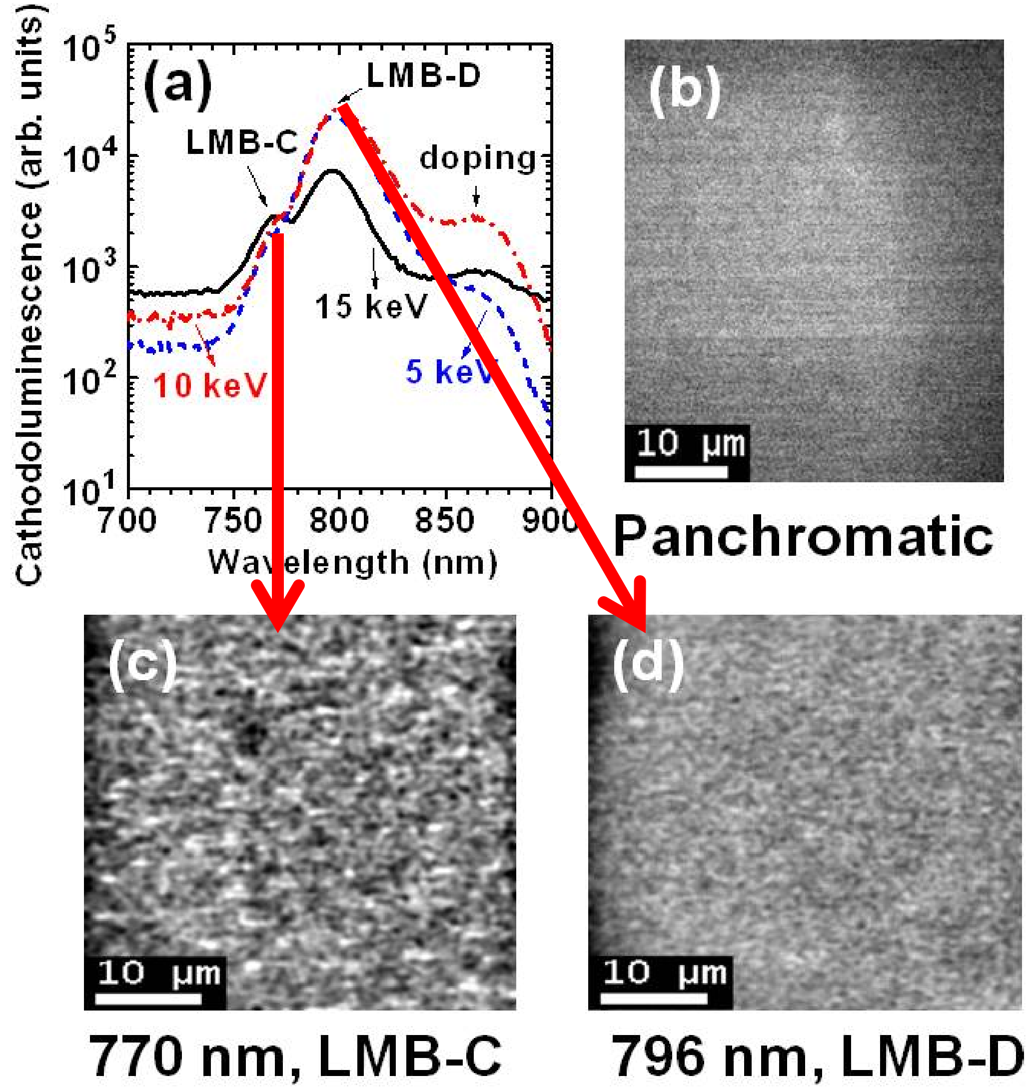


Defect density ~10^{5}cm^{-2}



No obvious non radiative defects observed

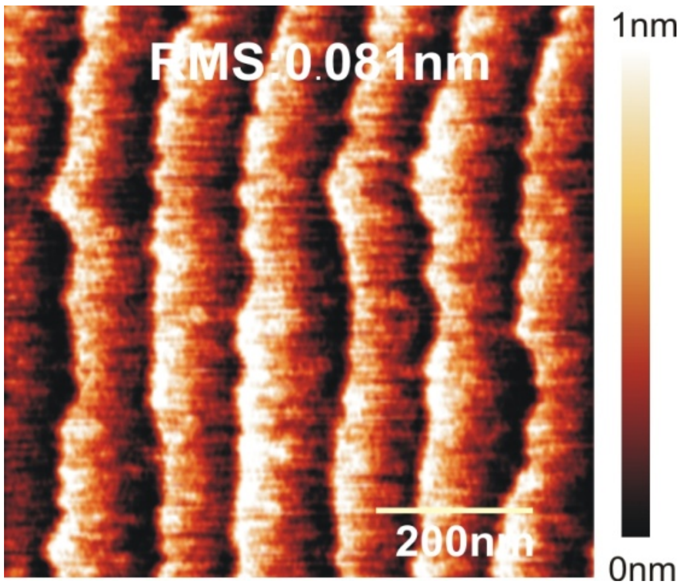




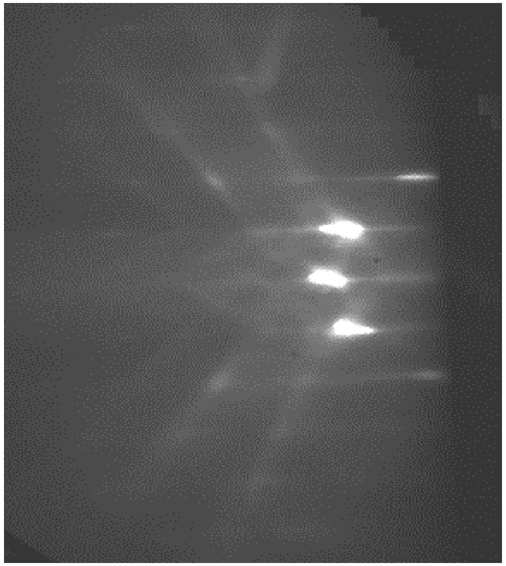
(a) CL spectra, (b) panchromatic CL image, (c) monochromatic CL image of LMB-C and (d) monochromatic CL image of LMB-D. In panchromatic image, the defectivity of LMB-C is not visible whereas monochromatic images show defectivity of LMB-C and defect free LMB-D.

MBE grown GaSb on GaAs (100)

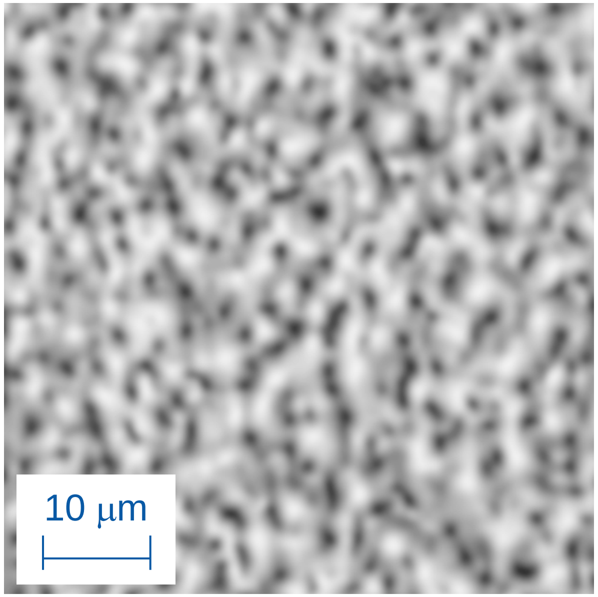
HRXRD FWHM of about 150 arcsecond,



in-situ AFM



RHEED

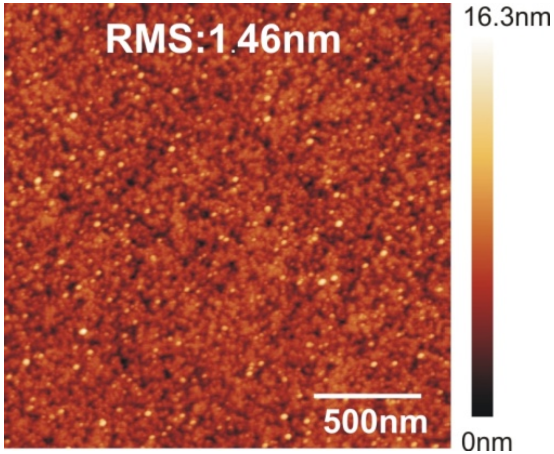


Cathodo-
luminescence

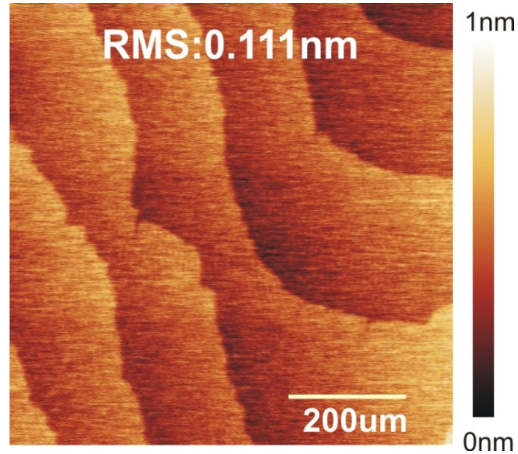
Dislocation density ~1 × 10^7 cm^{-2}

GaSb films on GaSb substrate

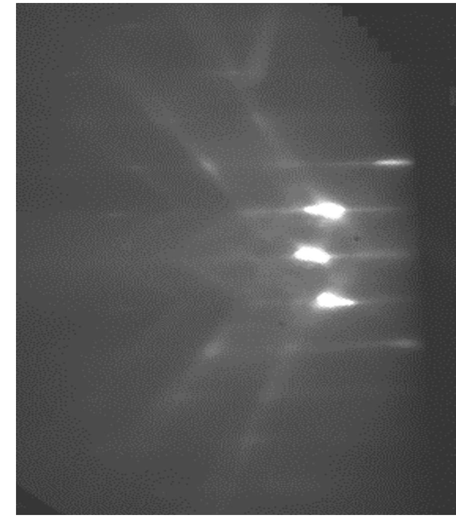
GaSb (100) homoepitaxial growth



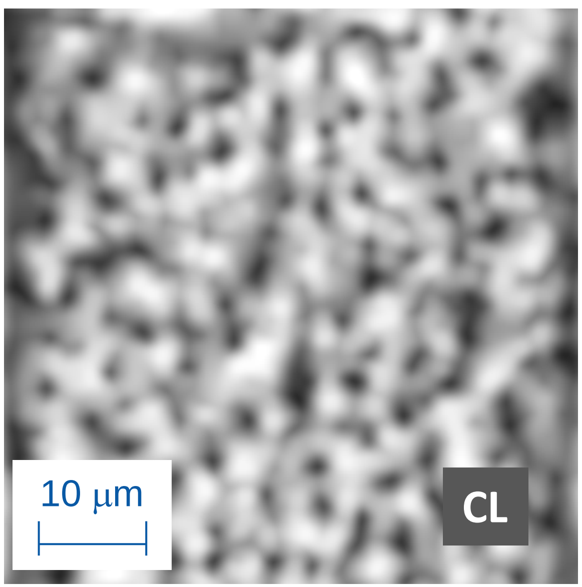
As-Received



GaSb film



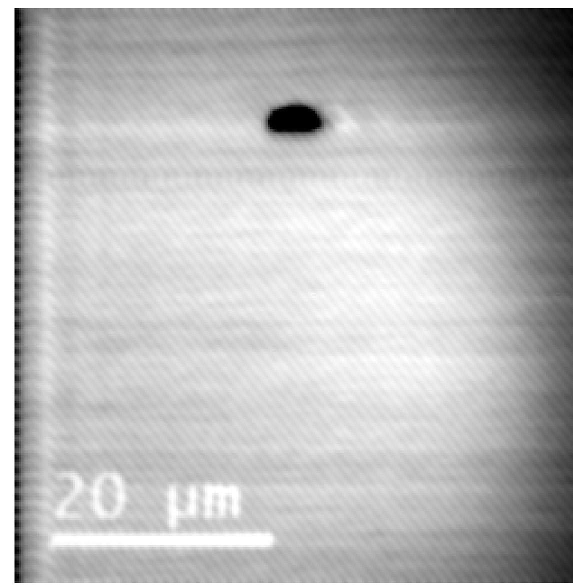
RHEED



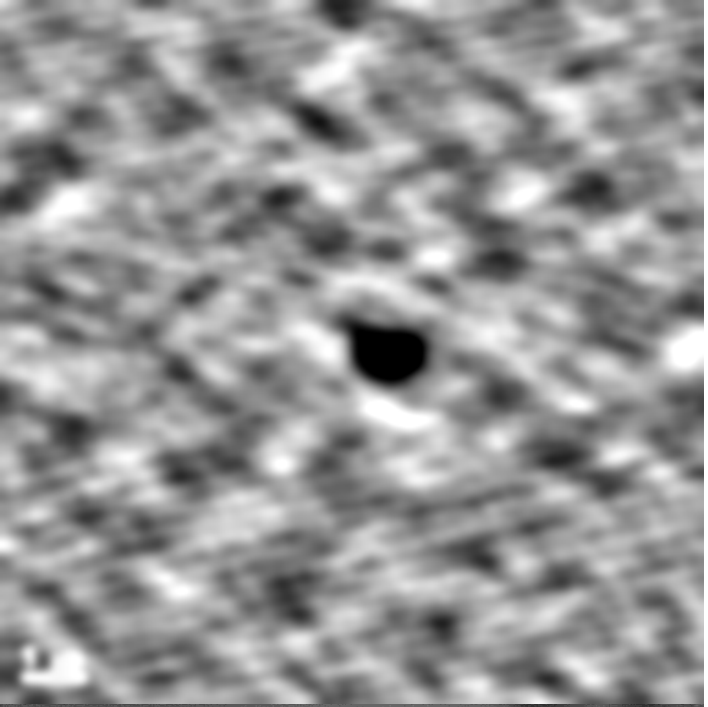
Bad surface prep

GaSb/GaSb
WaferTech (100) Sub

dislocation density
~1 × 10^5 cm^{-2}

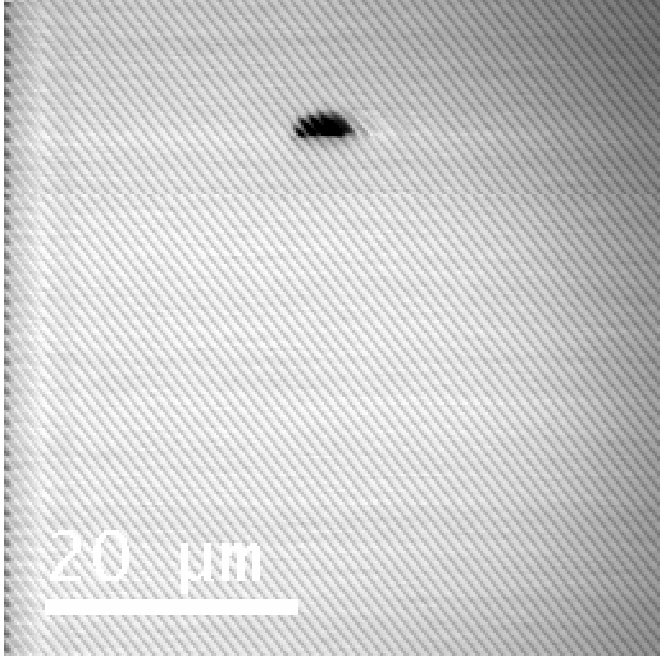


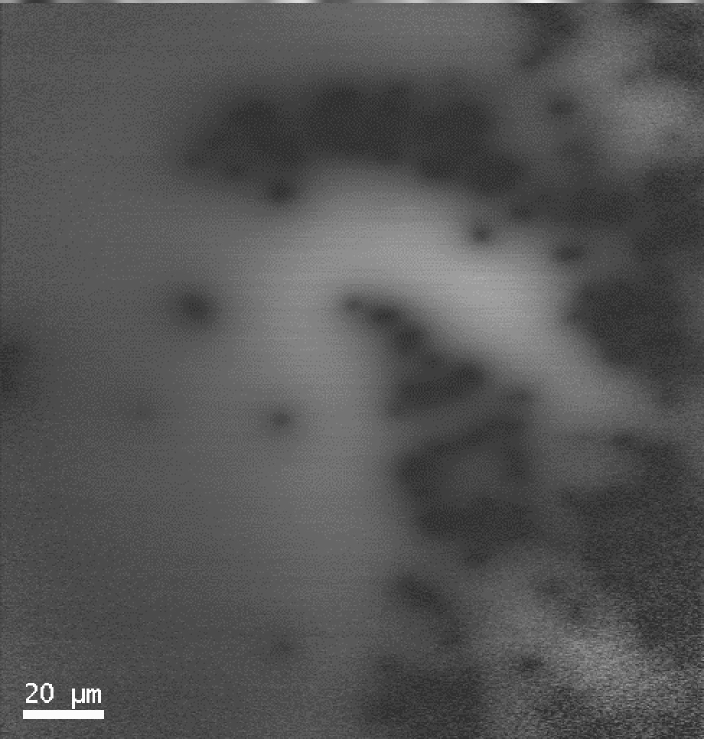
Good surface prep



InAs/GaAs

InAs/InAs

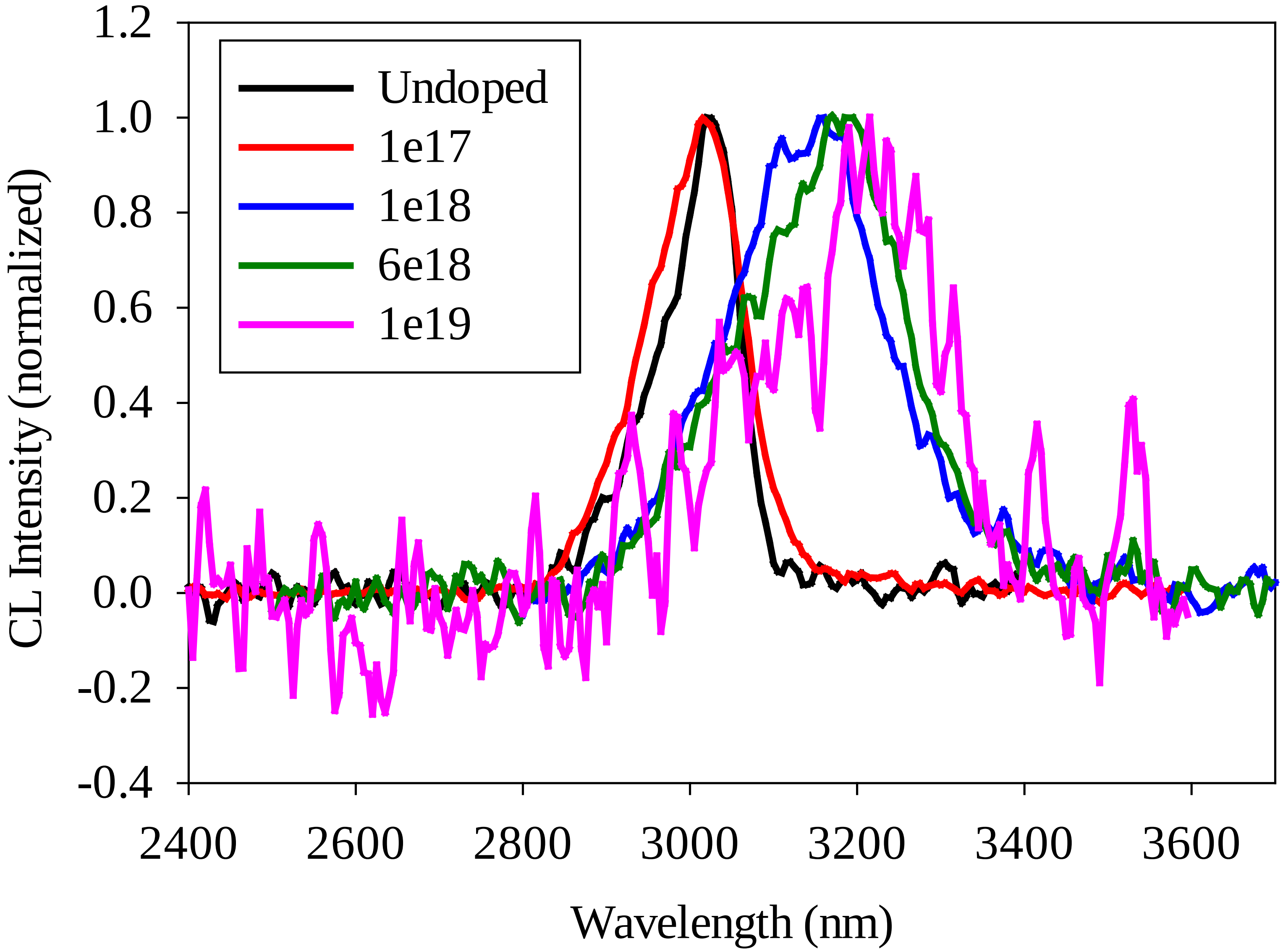


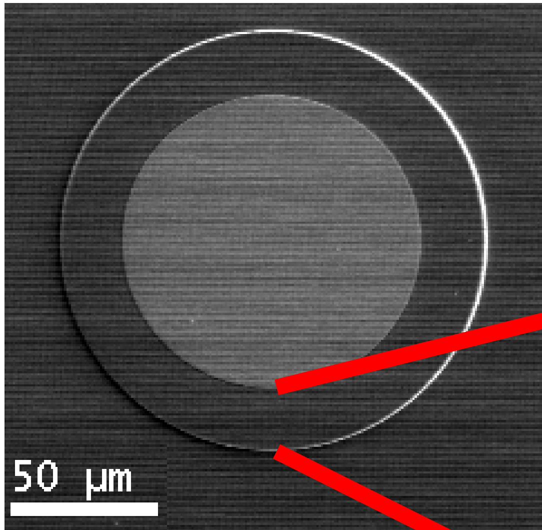


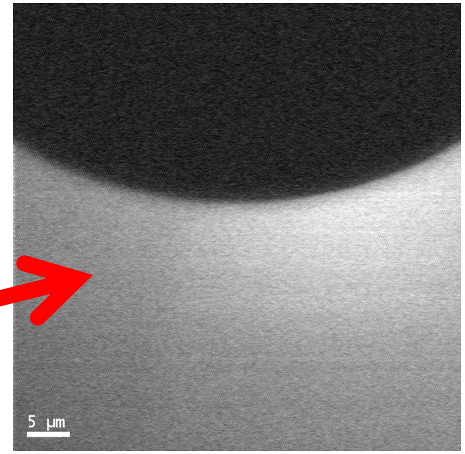
Defects in
InAs/GaSb SLS
(5 μm cutoff)

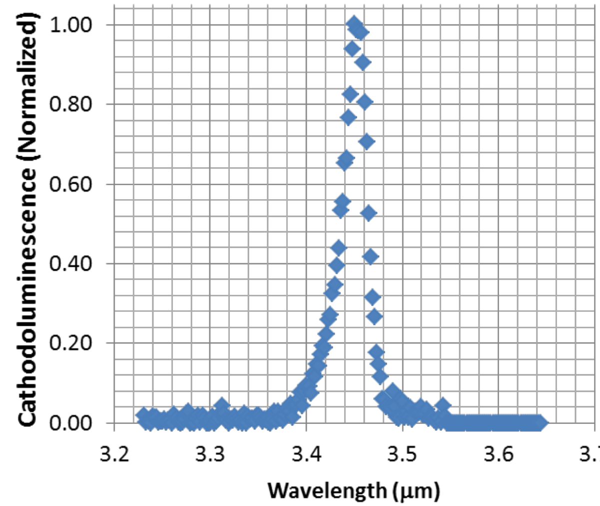
Various MWIR Images

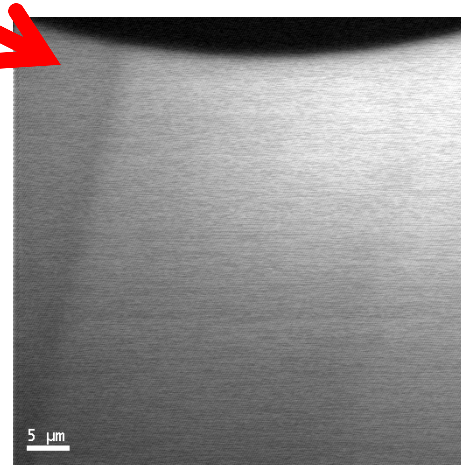
CL Spectra InAs Various doping levels (80K)

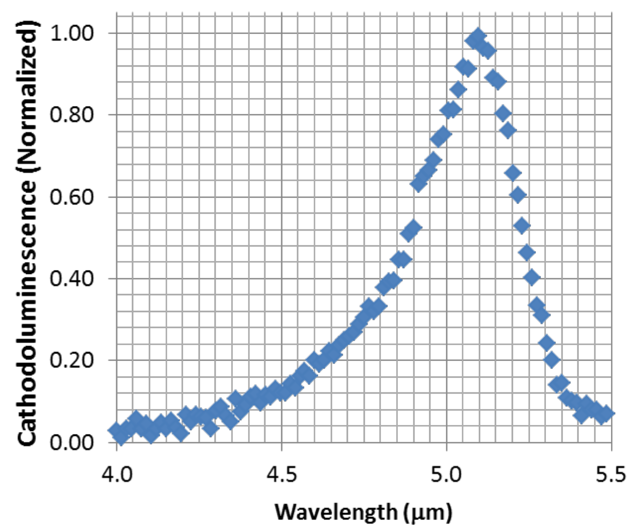












SEM (left) and CL (right) of a mesa diode structure

Spectral CL of InAs/GaSb SLS Structure (80K)

Questions?